I. C. 6476

JULY, 1931

DEPARTMENT OF COMMERCE

UNITED STATES BUREAU OF MINES
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MILLING METHODS AND COSTS AT THE ARGONAUT MILL, JACKSON, CALIF.

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MILLING METHODS AND COSTS AT THE ARGONAUT MILL, JACKSON, CALIF.[1]

By Selim E. Woodworth[2]

INTRODUCTION

This paper, describing the milling practice on the Mother Lode as typified in the mill of the Argonaut Mining Co. at Jackson, Amador County, Calif., is one of a series prepared by the United States Bureau of Mines.

The data herein presented and furnished through the courtesy of E. A. Stent, managing director and vice president of the Argonaut Co., covers operations from 1914 through the year 1929.

LOCATION

The stamp, amalgamation, and concentration mill of the Argonaut Mining Co. is located about 1 mile north of the town of Jackson, the county seat of Amador County. It is 1 mile south of the Amador Central Railroad at Martell. It is also situated at the apex of an imaginary equilateral triangle, the cities of Sacramento, the State capital, and Stockton, occupying the other corners of this geometrical figure. The distance between the points is about 50 miles. The mill stands at the top and spreads down the western slope of the hill covering the Mother Lode at this point. The collar of the main shaft of the mine is situated on the eastern slope of the same hill 120 feet below its crest.

MINE

The vein in the Argonaut mine varies in width from 15 to 60 feet. The ore has been continuous from the surface to a depth of 5,700 feet on the dip which at present is the depth of the lowest level in the mine. On the 4800-foot level the ore shoot had a length of over 1,400 feet. From the 4900-foot level to and including the 5400-foot level the ore was low-grade, but development at greater depth has shown the volume and value of the ore to improve. The ground is very heavy and swells rapidly, necessitating constant release of pressure behind timbers and the lowering of drift floors. "The swelling ground is in part the result of actual flowage of gouge into mine workings, an extrusion in the direction of the least resistance, and part is probably due to the imbibing of water by the colloidal material in the gouge."[3] Although a modified mining method of end slicing has been tried, the square-set method, with the fill kept within one set of all working faces, has been readopted.

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[1] - The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is used: "Reprinted from U. S. Bureau of Mines Information Circular 6476."

[2] - One of the consulting engineers, U. S. Bureau of Mines.

[3] - Knopf, Adolph, The Mother Lode System of California: U. S. Geol. Survey Prof. Paper 157, p. 26, 88 pp.

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ORE TREATED

Gold is the principal economic metal recovered; about 81 per cent of this occurs as coarse and fine metallic particles scattered through large quartz veins and enclosing slates. Coarse gold is most commonly found in the white quartz.

According to Knopf, the country rocks at the Argonaut are the same as at the Kennedy and "are composed of greenstone (augite melaphyre tuffs and breccias) and slate, with all the usual intermediate and gradational varieties between them."[4]

As a rule the quartz does not enter the footwall, which is very hard and stands well. It sometimes enters the hanging-wall fingering from the main ledge. The ore, as delivered to the primary breaker, has passed through a grizzly with 8-inch spaces and contains not more than 3 per cent of moisture.

An average of 69 per cent of the total value is recovered as bullion from amalgam, while the concentrates account for an additional 18 per cent. The concentrates are composed of auriferous pyrite, with small amounts of galena, sphalerite, chalcopyrite, tetrahedrite, pyrrhotite, and arsenopyrite. The latter mineral, very rich in gold, has been noted on the concentrating tables. As a usual condition, the presence of galena portends an increase in the gold content of the concentrates. The ore does not require fine grinding to liberate the values. The loss of gold in the tailings product amounts to 13 per cent, half of which is free gold contained in the carbonaceous or graphitic slimes.[5]

THE MILL

Prior to 1916 milling had been done in a 40-stamp mill located below the collar of the main shaft on the eastern slope of the hill covering the Mother Lode at the mine. Construction of the present 60-stamp mill was started that year, and during the latter part of 1916 20 stamps of the new mill were operated in conjunction with the old mill. The new mill did not reach full capacity until 1917, when the old one was scrapped. The present structure was designed to treat 300 tons of ore per 24 hours, and has exceeded that figure at times. The average amount of ore treated daily during the past 12 years has been 242 tons.

Figure 1 shows the general plan of the mill and indicates the flow of the pulp; Figure 2 shows a side elevation of the mill. The plant is built on a hillside, and the difference in elevation between the battery floor and the lower table floor is 66 feet.

METHOD OF MILLING

Figure 3 shows the general flow sheet of ore treatment, and is accompanied by a legend giving the details of equipment used. The treatment may be briefly summarized as follows:

1. Breaking to 2-1/2-inch size.
2. Crushing, by stamps, through a 24-mesh screen.

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[4] - Knopf, Adolph, Work cited. P, 67

[5] - Leaver, E. S., and Woolf, J. A., Re-treatment of Mother Lode Carbonaceous Slime Tails: Rept. of Investigations 2998, U. S. Bureau of Mines, 1930, 6 pp.

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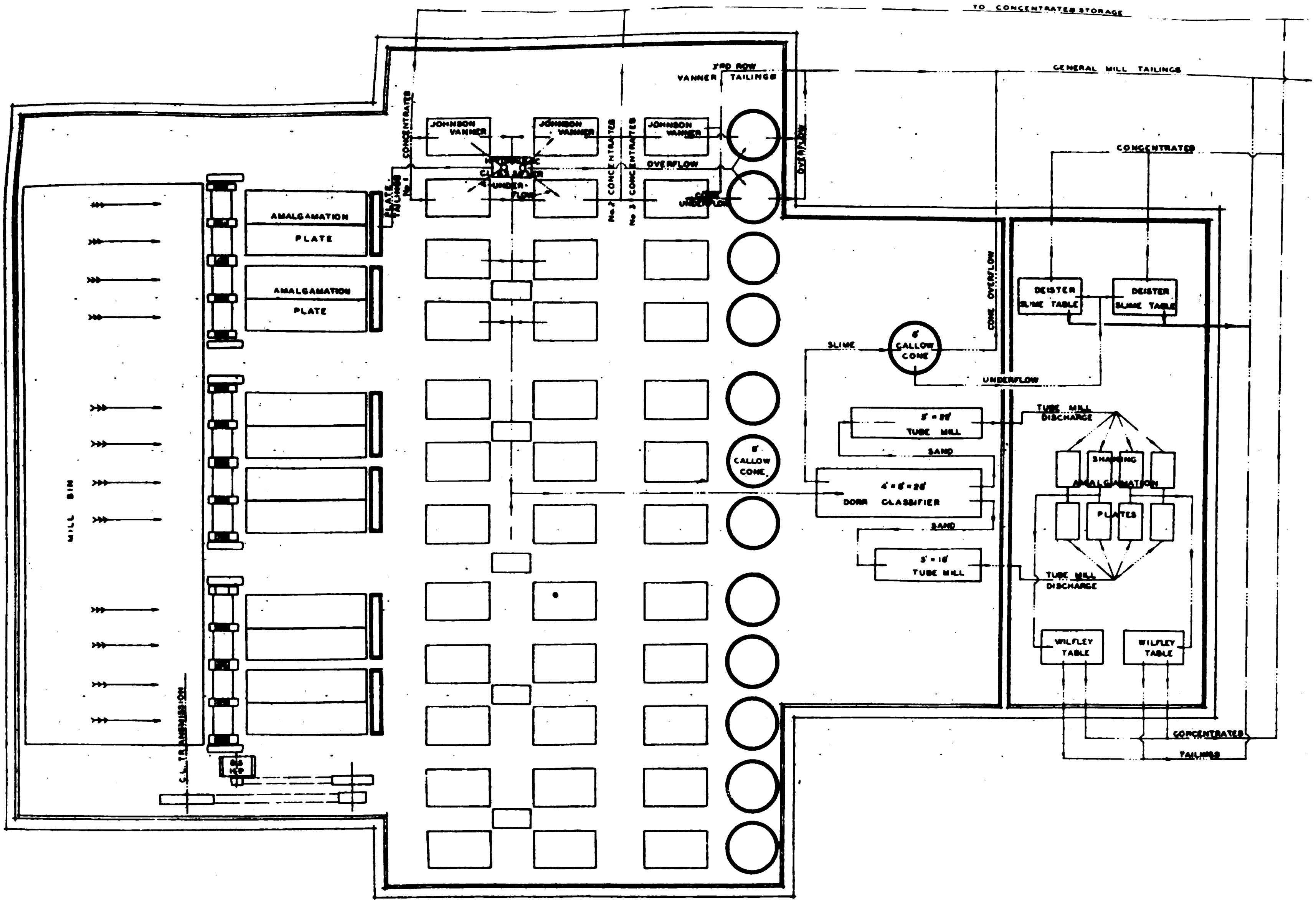

Figure 1.- General plan of mill. indicating the flow of pulp

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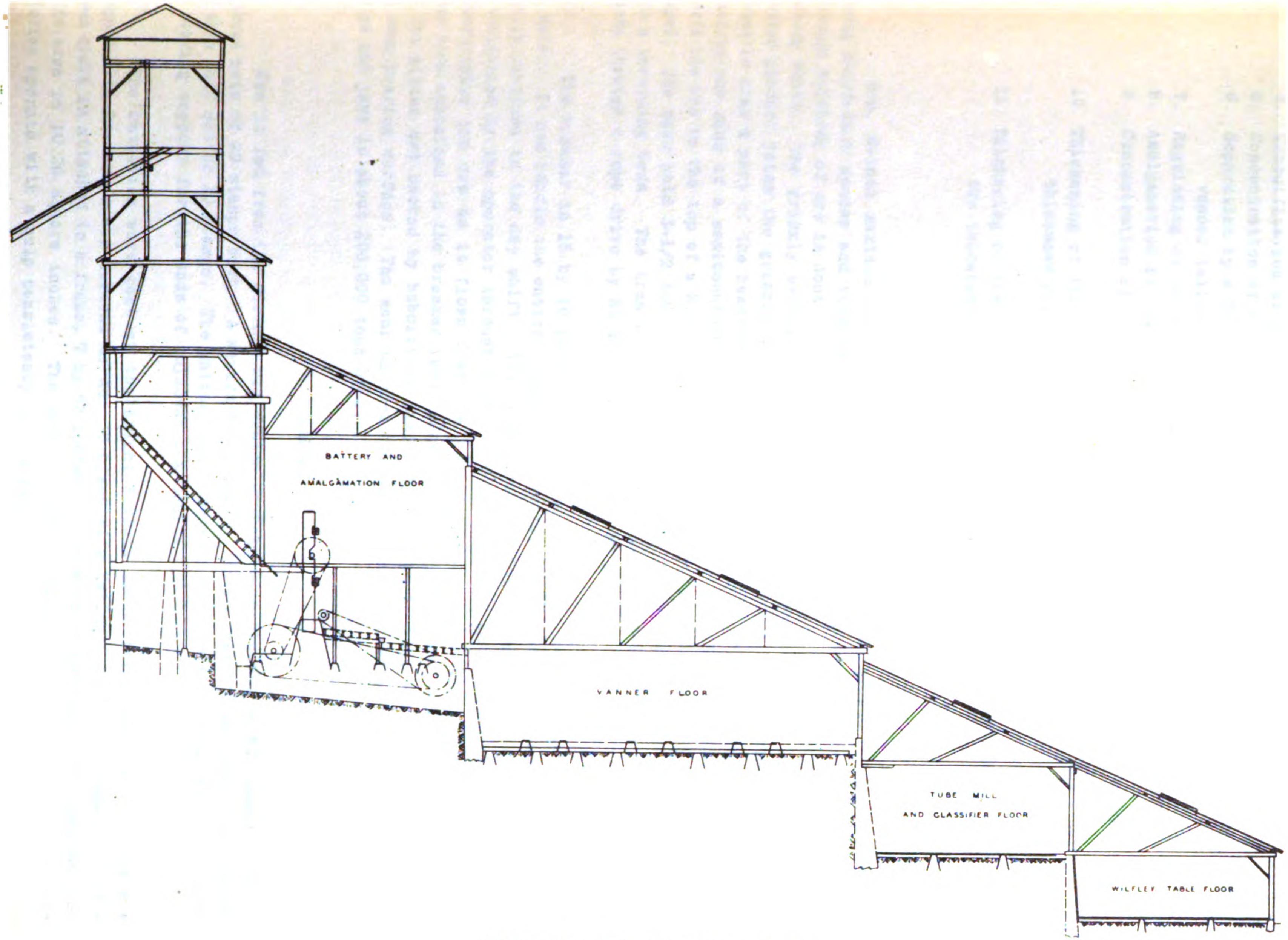

Figure 2.- Side elevation of mill

3. Inside and outside amalgamation.
4. Classification of plate tailings by spitzlutte classifiers.
5. Concentration of classifier spigot products by vanners.
6. Separation by a Dorr classifier of the coarser sands contained in the vanner tailings.
7. Regrinding of the Dorr-classifier sand product in tube mills.
8. Amalgamation of the tube-mill ground product on shaking plates.
9. Concentration of tailings from the shaking plates on Wilfley tables.

10. Thickening of the spitzlutte overflow pulp and concentration of the thickened pulp by vanners.

11. Thickening of the Dorr-classifier overflow pulp and concentration of the thickened pulp by Deister slime tables.

Breaking

Ore, 8-inch maximum size, is delivered from the underground skip to a grizzly having 2-1/2-inch spaces and located in a receiving bin which is a part of the headframe. Although hoisting of ore is done throughout the 24 hours, most of it is done during the early morning shift. The grizzly oversize is crushed to 2-1/2-inch size in a jaw breaker. The crushed product joins the grizzly undersize in a loading pocket of 300 tons capacity; this pocket is also a part of the headframe. From this bin the ore is delivered to a weigh-lorry which is one side of a semicounterbalanced, double-track, inclined-surface tram. The tram hoists the ore to the top of a 2,200-ton capacity mill storage bin where it is automatically dumped. The cars hold 3-1/2 tons each and are weighed on a Fairbanks track scale equipped with a recording beam. The tram is operated by a small double-drum hoist which in turn is driven through a rope drive by an 80-hp. variable-speed motor.

The breaker is 16 by 18 inches in size and is driven by a leather belt from a 35-hp. motor. It can handle the entire tonnage in 8 hours, and breaker operation is, therefore, usually confined to the day shift. The flow of ore to the grizzly which feeds the breaker is controlled by the operator through a rack and pinion chute gate. This operator has time to scrutinize the ore as it flows down the chute and is responsible for the rejection of tramp iron contained in the breaker feed. Jaw and frame plates are made of manganese steel and the plates are backed by babbitt so that they fit snugly into position, giving a full and even bearing surface. The wear on these plates is not excessive; the life of a set of plates and jaws is about 200,000 tons of ore.

Stamps

Ore is fed from the storage bin chutes by Challenge feeders to 60 stamps arranged in three sets of 20 stamps each. A separate cam shaft, driven from a line shaft, is allowed for each half set or 10 stamps. The battery post, between each 10-stamp set, acts as a common bearing support for the ends of adjacent cam shafts.

The batteries were cast at the Knight Foundry in Sutter Creek, Calif., and are equipped with 24-inch woven screens of No. 30 brass wire having 0.0277-inch openings. The screen cloth is attached to a frame, 7 by 52 inches inside measurements and the combined discharge area is 10.26 square inches. The usual height of discharge is about 7 inches; the batteries operate with a pulp consistency of 5.1 parts water to 1 part solids.

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The height of drop is 8 inches and the drop weight of each stamp is 1,285 pounds, distributed as follows:

	Pounds
Shoe	245
Die	130
Boss	280
Tappet	130
Stem	500
Total	1,285

Stamp stems are spaced 10 inches apart and the cam shafts are 5-5/8 inches in diameter. The stamps drop in the order 1-4-2-5-3 and at the rate of 96 drops per minute. White iron, imported from Sweden, is used by the Knight Foundry in casting dies for the mills in the district; shoes are made of forged steel. The average consumption of metal in pounds per ton of ore crushed is 0.422 for shoes and 0.282 for dies.

Amalgamation

Amalgamation is practiced both inside and outside the stamp batteries. For inside amalgamation, straight-sided, copper-faced, wooden chuck blocks are used. These blocks are equipped with half-round iron strips, spaced 2 inches apart, for their entire length. It was found that the half-round strips assisted amalgam to build up to a greater thickness than did the smoother block. If the hourly inspection of the chuck blocks indicates that mercury should be added, it is fed in measured quantities from a horn spoon with the incoming ore at the back of the batteries. The chuck blocks are cleaned twice a month or oftener, if need be. The total quicksilver fed is recorded and gives a very close estimate of the free-gold content of the ore crushed.

The pulp passing the battery screen falls upon reverse splash plates, the first of which is 5 by 51 inches in size with an area of 1.77 square feet, set at a slope of 3 inches per foot, and the second is 8 by 51 inches in size with an area of 2.83 square feet and an inclination of 4 inches per foot. There is a drop of 2 inches between these plates. On leaving the reverse splash plates, the pulp drops 5 inches to the cast-iron lip of the mortar. This drop is variable depending on the height of the battery discharge. From the mortar lip, the pulp falls 4 inches to an amalgamated apron plate, set at a slope of 1-1/4 inches to the foot. This plate is 49 by 58 inches in size and has an area of 19.4 square feet. An amalgam trap consisting of a wooden box of length equal to the width of the plate and of a uniform depth of 8 inches is attached to and forms a part of the apron frame. The pulp flows from this trap through four 2-inch iron nipples, set in the side of the box, on a plane 4 inches from the bottom. The pulp, issuing from these nipples, drops through a 10-mesh, woven-wire, brass screen to the sluice plate. If a battery screen is punctured, this 10-mesh screen catches the coarse oversize. The total drop from the discharge nipples of the trap to the sluice plate is 6 inches. This plate is set at an inclination of 1-1/4 inches per foot and is 46-1/2 inches by 16 feet in size. It has an area of 62.10 square feet. The total length of plates per battery is about 21 feet and the total plate area is 86 square feet. On the average tonnage this represents about 4.3 square feet of plate area per ton of ore milled per day. As the pulp leaves the sluice plate it drops into another amalgam trap which is attached to and forms a part of the plate frame. This trap is a wooden box built the entire width of the plate, but unlike the first trap it has a sloping bottom; and the depth of sand adjacent to the plate discharge is but 4 inches, whereas the depth along the trap's overflow is 6 inches. All plates, including the chuck blocks, are made of copper which weighs 5 pounds per square foot and are electroplated with 3 ounces of silver per square foot of contact surface.

When the tube mills operate and grind the sands from the classifier which treats the tailings of the first two rows of vanners, the ground product is amalgamated on eight shaking plates 4 by 5 feet in size, which have a combined area of 160 square feet. These plates are set upon a slope of 3/4-inch per foot and are oscillated 90 times per minute by a simple strap eccentric.

Each morning the amalgam on the apron and sluice plates is softened with mercury, rubbed with a rag, cleaned with a rubber squeegee and dressed with a whisk broom for the day's operation. The cleaning and conditioning of these plates requires about 3-1/2 hours. The monthly clean-up, including retorting of amalgam and melting of bullion, occupies five days. On the first day of the clean-up all sluice plates are cleaned and scraped with wide-faced putty knives, and in addition one battery is dismantled, cleaned, and reassembled. During the second day six apron plates are cleaned and scraped with a scraper made from an old file, the end of which has been flattened, widened, sharpened, and turned at right angles to its length. Two additional batteries are cleaned up on this day. On the third day the remaining six apron plates are cleaned and scraped, and three more batteries are cleaned out. During the fourth day all splash plates are taken to the clean-up room to be steamed and scraped, and, in addition, four batteries are cleaned up. The two remaining batteries are cleaned on the fifth day.

The amalgam recovered from dressing the plates each day is squeezed into a pellet and stored until retorted with the general clean-up amalgam. Residues taken from the batteries are placed in an amalgam barrel which contains three pieces of stamp stem and which is rotated for about 12 hours. Mercury, amounting to 350 troy ounces, is then placed in the barrel, which is again rotated for an additional hour or two. It is then stopped, opened, cleaned, and the muck run into a storage box under the barrel. From here the pulp is fed by the clean-up man to a power jig, the bed of which forms on a fine wire screen. The amalgam is found in the hutch of the jig with the iron floating on the amalgam and the sand over the iron. When all of the barrel charge has passed through the jig, the sand is scooped from the hutch, the iron is removed by a magnet, and the liquid amalgam is drawn through a spigot into an iron dipper. Here it is further cleaned by mechanical agitation and a water jet which removes any foreign matter present. After squeezing the cleaned amalgam in a canvas cloth by hand and removing most of the liquid mercury, additional mercury is removed by further squeezing the soft amalgam in canvas, using a mould and a hydraulic press.

The final amalgam from the clean-up, placed in trays, is sealed in the retorts during the afternoon of the fifth day. The retorts are heated and the quicksilver volatilized and condensed during the night. Wood is used for fuel. The next morning, the sixth day, the bullion sponge is removed from the warm retort, placed in graphite pots, and, after melting in oil-fired furnaces, is poured into bricks which are shipped at once either to the American Smelting and Refining Co. at Selby or to the United States mint at San Francisco. The trays into which the amalgam is placed for retorting are painted with a chalk and water emulsion which is thoroughly dried before using. The chalk coating assists in a clean removal of the gold sponge after retorting.

The fineness of the bullion shipped for the past 15 years averages 821 parts of gold, 159 parts of silver, and 20 parts of base metals. No particular effort is made to remove base metals in melting the gold sponge. The average value of bullion recovered per ounce of quicksilver fed is $11.44, while the bullion value per ounce of hard amalgam is $7.25. Mercury loss has averaged 0.17 troy ounce per ton of ore milled.

Concentration

Since 1928, the concentrating equipment for each 10 stamps has consisted of one spitzlutte-type classifier, six 6-foot Johnson or Frue vanners, and one 8-foot Callow cone equipped with a gooseneck discharge. The spitzlutte sizer is a two-spigot machine of local design and manufacture.

The pulps from two 5-stamp batteries unite in one launder and drop into one end of the spitzlutte classifier. The slimes overflow from the opposite end and are conveyed to the 8-foot Callow cone. The first spigot discharge of the spitzlutte classifier is split between two of the first-row vanners, which handle the coarsest material. The second spigot discharge is split between two of the second-row vanners, which treat the intermediate size of material. The gooseneck discharge of the Callow cone is split between two third-row vanners, which handle the finest material. The overflow of the Callow cone passes to the general mill tailings.

Each vanner operates at 180 oscillations per minute, has a belt speed of about 4 feet per minute and treats 8 tons of solids per 24 hours. The percentage weight of vanner concentrates recovered, based on the ore treated, is variable, depending on the location in the mine from which the ore is obtained. It varies from 1.96 to 3.5, averaging about 2-1/2 per cent.

Since 1928 the overflow of the Callow cone and the tailings from the three rows of vanners have made up the general mill tailings. However, when the value of the general tailings warrants further grinding, the tailings from the first two rows of vanners which treat the coarser products are classified in a Dorr duplex classifier operated in open circuit with two tube mills. The sand is ground in these mills and after passing over shaking amalgamating plates is concentrated on Wilfley tables. The overflow pulp from the Dorr classifier is thickened in a Callow cone, the underflow of which is concentrated on Deister slime tables. Tailings from the Wilfley and Deister tables, the overflows of the thickening cones, and tailings from the third-row vanners comprise the general mill tailings which pass to the Amador Metals Reduction Co. for cyanide treatment.

The belt machine, or vanner, has always been the standard on the Mother Lode. Various types of shaking sand and slime tables have been installed and tried, but as a rule have been rejected for the vanner, because it is difficult for mill foremen who have grown up with vanner milling practice and have no first-hand knowledge of other means of concentration to realize that methods and costs have improved with time. However, concentration must be employed with these ores, for the gold contained in the sulphide minerals accounts for about 20 per cent of the total value. Flotation heretofore has been of doubtful advantage, owing to the large bulk and low grade of concentrates obtained. This is due to the carbonaceous and colloidal contents of the slime. Reagents have lately been developed which may make it possible to employ flotation for concentrating Mother Lode ores.[6]

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6 - Leaver, E. S., and Woolf, J. A., work cited.

Table 1 shows screen analyses of stamp feed and mill products for the period 1930.

Table 2 gives gold assays of mill heads and products for yearly periods from 1915 to 1929, inclusive.

Table 3 presents metallurgical data for yearly periods from 1915 to 1929, inclusive.

Table 1.—Screen analyses of mill products for period April, 1930

Screen size	Weight, per cent						
	Stamp feed	Plate discharge, feed to spitzlutte classifier	Classifier spigot No. 1, coarse feed to vanners	Classifier spigot No. 2, medium feed to vanners	Classifier overflow, feed to Callow cone	Callow cone underflow, fine feed to vanners	Mill tailings
Plus 3-inch ring	0.00	-	-	-	-	-	-
Plus 2-inch ring	5.66	-	-	-	-	-	-
Plus 1-inch ring	46.90	-	-	-	-	-	-
Plus 3-mesh..........	33.00	-	-	-	-	-	-
Plus 4-mesh...... ...	3.55	-	-	-	-	-	-
Plus 6-mesh..........	1.92	-	-	-	-	-	-
Plus 8-mesh..........	1.36	-	-	-	-	-	-
Plus 10-mesh........	1.23	-	-	-	-	-	-
Plus 14-mesh........	1.10	-	-	-	-	-	-
Plus 20-mesh........	1.01	-	-	-	-	-	-
Plus 28-mesh........	.76	-	-	-	-	-	0.7
Plus 35-mesh........	.70	9.97	2.30	-	-	-	8.2
Plus 48-mesh........	.55	17.09	9.29	-	-	-	13.8
Plus 65-mesh........	.48	22.92	12.28	4.22	-	-	18.9
Plus 100-mesh......	.46	19.31	16.42	14.25	-	-	15.7
Plus 200-mesh......	.55	15.11	17.57	41.05	6.06	14.20	23.0
Minus 200-mesh....	.77	15.60	42.13	40.50	93.94	85.80	19.7

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Table 2.—Gold assays of mill heads and products for yearly periods from 1915 to 1929, inclusive

Year	Gold assays, dollars per ton														
	1915	1916	1917	1918	1919	1920	1921	1922	1923	1924	1925	1926	1927	1928	1929
Heads	13.06	12.96	12.37	15.11	14.21	16.52	10.87	10.22	11.22	10.16	8.45	6.35	6.34	8.03	6.07
Amalgamation															
Bullion value per ton of ore	9.27	9.10	8.73	10.80	10.42	12.45	7.51	7.75	7.71	7.11	5.92	3.96	4.02	4.88	3.82
Concentration															
Heads	3.79	3.86	3.64	4.31	3.79	4.07	3.36	2.47	3.33	3.05	2.53	2.39	2.32	3.15	2.25
Vanner concentrates	107.50	106.90	91.88	135.29	115.23	119.02	95.08	118.74	52.23	57.92	53.36	61.60	59.75	70.82	64.89
Buddle concentrates	52.78	56.40	53.18	57.24	53.00	51.50	40.30	47.21	(2)	-	-	-	(3)	-	-
Tailings	1.87	1.89	1.71	2.01	1.89	1.96	1.69	0.93	1.22	1.22	1.05	1.02	0.87	1.23	0.68

1 - Total ore milled 1,045,609 tons.

2 - Buddle and vanner concentrates mixed and sampled as vanner concentrates.

3 - Buddle concentration discontinued after 1926.

Table 3.—Metallurgical data for yearly periods from 1915 to 1929, inclusive

Year	1915	1916	1917	1918	1919	1920	1921	1922 (3)	1923	1924	1925	1926	1927	1928 (4)	1929
Ore milled, tons	68,386	62,723	71,965	73,569	66,137	21,406	53,830	64,134	33,864	88,000	87,611	90,400	83,000	90,900	89,684
Days operated	365	317	363	350	298	(1) 79	262	(2)247	198	365	365	365	336	365	365
Ore milled per 24 hours, tons	187	198	198	201	222	271	205	260	171	241	240	247	238	249	246
Weight of feed recovered as concentrates, per cent	1.96	1.99	2.19	2.57	2.85	2.92	2.77	2.05	3.53	2.90	2.88	2.16	2.40	2.69	2.42
Bullion recovered per ounce of amalgam, dollars	7.21	7.29	7.03	7.15	7.57	7.38	7.30	7.64	7.71	7.27	7.00	7.00	6.88	6.94	7.21
Bullion recovered per ounce of mercury fed, dollars	11.34	10.25	9.14	10.37	10.76	13.05	10.15	12.92	14.89	13.62	13.50	10.99	9.72	10.90	11.34
Gold recovered as amalgam, per cent	71.00	70.20	70.50	71.30	73.90	75.40	69.20	76.00	70.00	76.00	70.00	62.50	63.50	62.60	64.89
Bullion recovered per ton of ore, dollars	9.27	9.10	8.73	10.80	10.42	12.45	7.51	7.75	7.71	7.11	5.92	3.96	4.02	4.88	3.82
Vanner concentrates recovered per ton of ore, dollars	1.78	1.78	1.80	1.44	1.13	1.07	0.96	1.06	1.84	1.68	1.43	1.34	1.45	1.92	1.57
Buddle concentrates recovered per ton of ore, dollars	0.14	0.19	0.13	0.86	0.77	1.04	0.71	0.48	0.27	0.15	0.05	0.03	(5)	-	-
Tailings loss per ton, dollars	1.87	1.89	1.71	2.01	1.89	1.96	1.69	0.93	1.22	1.22	1.05	1.02	0.87	1.23	0.68
Head value calculated, dollars	13.06	12.96	12.37	15.11	14.21	16.52	10.87	10.22	11.04	10.16	8.45	6.35	6.34	8.03	6.07
Head value by assay, dollars	13.00	12.93	12.32	13.10	14.37	12.45	11.70	10.20	11.00	10.13	7.44	5.75	6.69	7.80	6.26
Mill extraction, per cent	85.95	85.70	86.46	87.20	87.20	88.40	86.00	91.00	89.30	88.30	88.60	83.84	86.18	85.04	89.03
Mercury consumption per ton of ore, troy ounce	-	0.125	0.253	0.320	0.291	0.250	0.229	0.154	0.153	0.115	0.098	0.102	0.109	0.126	0.113

Die consumption per ton of ore, pounds	(Averaged for the period)	0.282
Shoe consumption per ton of ore, pounds	(Averaged for the period)	0.422
Net water consumption per ton of ore, gallons	(For the year 1929)	1,425

1 - Mine fire.
2 - Second underground fire.
3 - Tube mill and shaking plates installed and operating.
4 - Tube mills shut down.
5 - Buddles did not operate after 1926.

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DISPOSAL OF TAILINGS

The mill tailings are conveyed through a 3,000-foot concrete lined redwood launder set on a 2-1/2 per cent grade to the cyanide plant of the Amador Metals Reduction Co. where they are treated under contract. After treatment, the Amador Co. stacks the residues within a dam built of sand and slime erected in a large gulch which empties into a clarifying reservoir behind a multiple-arch concrete dam. This structure was erected by the Argonaut Mining Co. in compliance with the ruling of the California State Debris Commission which limited to one-half of 1 per cent the quantity of solids that may be discharged into any stream entering San Francisco Bay. Residues have been so carefully stacked that more than 75 per cent of the original under-water storage volume is still available after milling more than one million tons of ore.

WATER SUPPLY

Water for milling purposes is delivered by the Pacific Gas and Electric Co. at $0.20 per miner's inch to the 7,000,000-gallon capacity reservoir of the Argonaut Mining Co. From this reservoir it flows through a combination wood and steel inverted syphon, about 3,000 feet long, to a surge tank at the mill from which it is pumped to the mill tank. The mill uses water at the rate of about 240 gallons per minute, which is equivalent to about 5.7 tons of water per ton of ore milled.

POWER

(For the year 1929)

Electric power is supplied by the Pacific Gas and Electric Co., under Schedule P5, known as "The Prime Industrial Power Series Schedule." This schedule is based upon a variable charge per kilowatt hour per maximum demand in any 30-minute period and also upon the power factor for electric energy delivered to the mine company's transformers. The Argonaut Co. accepts delivery at 17,000 volts, stepping it down to 2,300 volts for underground use and 440 volts for use on the surface. The average mill power load is 275 kilowatts when the tube-mill section is not operating. The consumption of power is 19.50 kilowatt hours per ton of ore milled. Power costs $0.008744 per kilowatt hour.

SAMPLING

The head sample is taken from the cars of the counterbalanced surface tram leading to the mill storage bin. After these cars are loaded, a double hand sample is taken from the top of each car. The separate samples are combined and represent the mill heads. The mill concentrates after being shoveled from the vanner boxes to the transport buggy are sampled by spearing with a split pipe. The average results obtained on the mill sample closely check the results on the sample obtained by the purchaser. If, however, the vanner boxes rather than the transport buggy are sampled by spearing, the results are erratic and unreliable. The mill tailings are sampled by an automatic swing sampler of local design and construction. This sampler cuts the entire stream of tailings pulp every 10 minutes and is actuated by a tipping water box.

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LABOR

When the tube mills are not operating, which is the condition prevailing since 1928, there are seven men on the day shift and three men on each of the other two shifts, making a total crew of 13 men. The wage scale per shift is as follows:

Vanner men..........	$4.00
Battery helpers	4.00
Battery men........	4.50
Mechanics............	5.00
Shift bosses......	5.50 to 6.75
Mill boss...........	8.00

The average daily wage is $5.10 per man per 8-hour shift. When the tube mills operate, three additional men are required, at a wage of $4.00 each.

COSTS

Table 4 presents summaries of costs for yearly periods from 1915 to 1929, inclusive.

Table 5 gives costs in units of labor and power for the year 1929.

Table 4.—Summary of costs for yearly periods from 1915 to 1929, inclusive

	Dollars per ton of ore milled														
Year	1915	1916	1917	1918	1919	1920	1921	1922	1923	1924	1925	1926	1927	1928	1929
Labor......................	0.22	0.20	0.24	0.24	0.24	0.26	0.26	0.27	0.38	0.31	0.29	0.27	0.31	0.28	0.23
Power, lights, and water[1]........	-	-	-	-	-	-	-	-	-	-	.19	.13	.14	.16	.19
Supplies................	.25	.24	.31	.31	.36	.41	.35	.37	.46	.44	.11	.10	.15	.15	.10
Trucking[2]..............	-	-	-	-	-	-	-	-	-	-	.03	.02	.02	.02	.03
Concentrates treatment..........	.20	.22	.23	.34	.34	.36	.34	.33	.57	.48	.39	.33	.38	.44	.38
Insurance..............	-	-	-	-	-	-	-	-	-	-	.04	.02	.02	.02	.01
Miscellaneous......	-	-	-	-	-	-	-	-	-	-	.04	.03	.01	.02	.02
Total cost of milling.............	0.67	0.66	0.78	0.88	0.94	1.03	0.95	0.97	1.41	1.23	1.09	0.90	1.03	1.09	0.96

1 - Included in "Supplies" for years 1915 to 1924, inclusive.

2 - Included in "Concentrates treatment" for years 1915 to 1924, inclusive.

Table 5.—Summary of costs in units of labor and power for the year 1929

Labor, tons of ore per man-shift of 8 hours	Operation	Maintenance
Stamping	81.3	112.4
Amalgamating	81.3	-
Concentrating	81.3	244.0
Superintendence	244.0	-
Total labor	18.90	-
Power	**Kilowatt hours per ton of run-of-mine ore**	**Percentage of total power**
Stamping	13.74	70.70
Concentrating	3.33	17.10
Pumping water	2.38	12.20
Total	19.45	100.00

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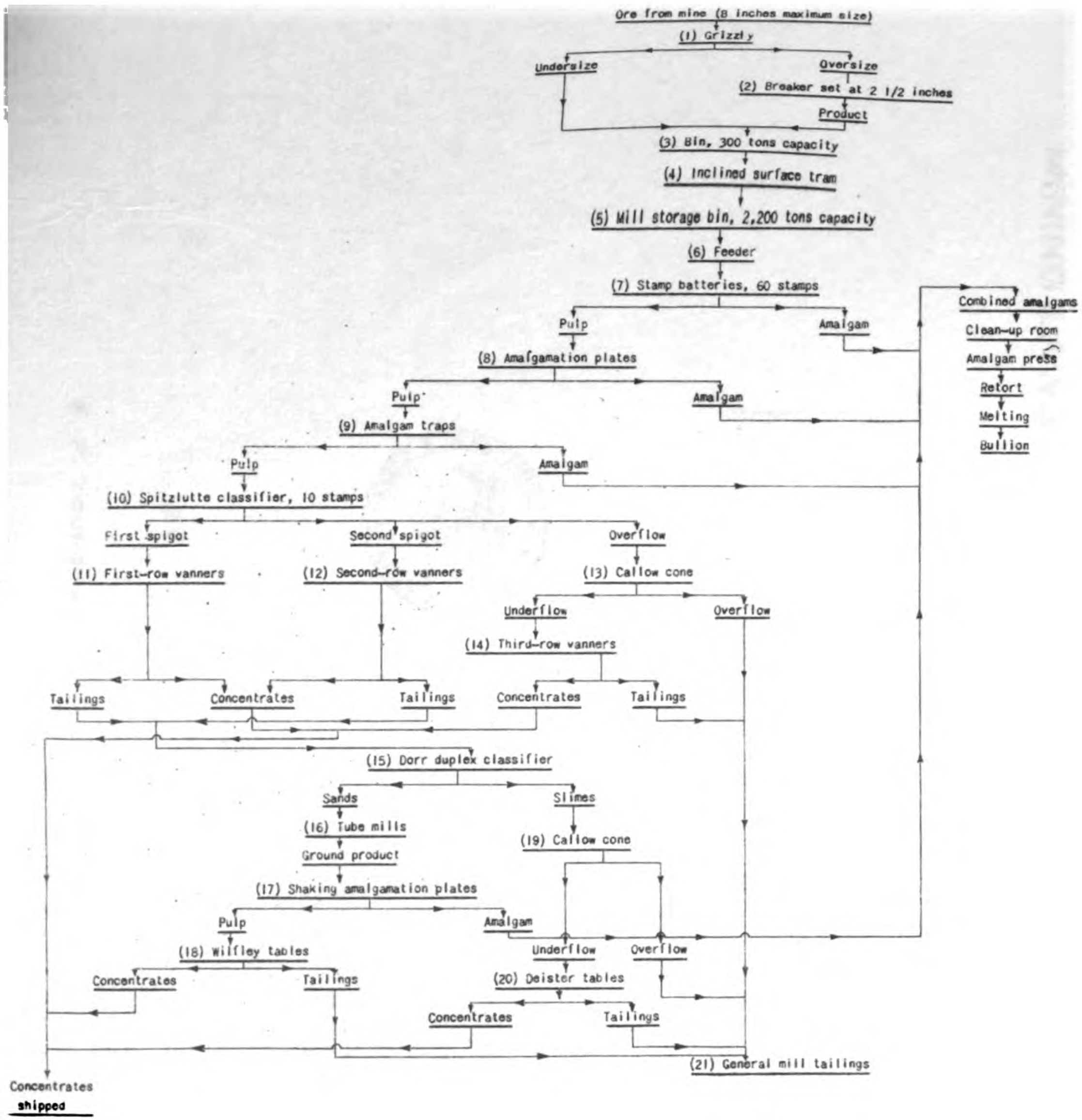

Figure 3.- Flow sheet of ore treatment

Legend

(1) Grizzly with 2 1/2-inch spaces, receives ore of 8 inches maximum size.
(2) Jaw breaker, 16 by 18 inches in size, manufactured by the Knight Foundry, Sutter Creek, Calif.
(3) Surface ore bin, 300 tons capacity, has a sloping bottom and is part of the headframe. The undersize of the grizzly and the breaker product are delivered to this bin.
(4) Inclined surface tram of semicounterbalanced construction. Cars hold 3 1/2 tons each and are charged from a rack and pinion controlled chute gate leading from the surface ore bin.
(5) Mill bin constructed with inclined bottom. The bin holds 2,200 tons of ore and feeds twelve 5-stamp batteries through rack and pinion chute gates.
(6) Challenge feeders.
(7) Twelve 5-stamp batteries; each stamp weighs 1,200 pounds.
(8) Amalgamation plates; total length per battery is 21 feet and plate area per battery is 86 square feet.
(9) Amalgam traps built into amalgamating plate holding frames.
(10) Spitzlutte classifier, two spigots and an overflow; one classifier for 10 stamps.
(11) Johnson or Frue vanners, 6-foot size. Each spitzlutte first-spigot product is treated by two machines.
(12) Johnson or Frue vanners, 6-foot size. Each spitzlutte second-spigot product is treated by two second-row machines.
(13) Callow cone, 8-foot size; one cone for each spitzlutte. The overflow pulp goes to the general mill tailings and the underflow product is treated by two third-row Johnson or Frue vanners.
(14) Johnson or Frue vanners, 6-foot size.
(15) Dorr duplex type-C classifier, receives, as feed, the combined tailings products of the first two rows of vanners.
(16) Two tube mills for regrinding classifier sands; one mill is 5 by 18 feet and the other is 5 by 22 feet.
(17) Eight shaking amalgamation plates which oscillate at 90 strokes per minute. Each plate has an area of 20 square feet.
(18) Two Wilfley tables treating the ground sand after amalgamation.
(19) One 8-foot Callow cone which thickens the Dorr classifier overflow product and delivers an overflow product which is discarded and a thickened pulp which is treated on two Deister slime tables.
(20) Two Deister slime tables.
(21) General mill tailings, delivered under contract to the cyanide plant of the Amador Metals Reduction Co. This company is responsible for stacking its plant residues so as to conserve storage space.
(22) Contrates, shipped to the Amador Metals Reduction Co.